

OTOLITHS AND OTHER FISH REMAINS FROM THE TIMMS POINT SILT (EARLY PLEISTOCENE) AT SAN PEDRO, CALIFORNIA

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ABSTRACT: Over 1,000 pounds of fossiliferous Timms Point silt yielded 2,601 otoliths, 121 vertebrae, 68 teeth, 2 dermal denticles, and 1 fin spine. These remains had come from a minimum of 62 species (53 bony fishes and 9 elasmobranchs) belonging to 54 genera in 30 families. Nine of the 53 teleost species belong to two families of deep-sea fishes (Myctophidae and Melamphaidae) that seldom have been captured in water shallower than 1,000 feet, and six other species are "northern" forms that have not been noted within several hundred miles of the Timms Point locality during modern times.

An exposure of Timms Point silt near the type section at San Pedro, California, was sampled by personnel from the Los Angeles County Museum of Natural History on several occasions during the past decade. Fossiliferous matrix collected at this site (LACMIP 130) during these field trips was washed and processed as explained in a previous publication (Fitch, 1966), and all fish remains were removed and saved. A small number of fish remains recovered by Museum personnel working under the supervision of George P. Kanakoff, then Curator of Invertebrate Paleontology, was also used in this study, as were many otoliths found by Dr. Charles R. Wright, Sanger, California, in material he had collected at Timms Point during recent years. In addition, 94 otoliths, 3 teeth, and 1 dermal denticle identified for William Zinsmeister, Long Beach, California, during January and February 1968, have been retained in his collection. These remains represented at least 20 species (2 elasmobranchs and 18 teleosts), two of which, *Prionace glauca* and *Squatina californica*, were not among the 2,507 otoliths, 65 teeth, and 1 dermal denticle previously examined from this deposit.

Clark (1931) described three units of Timms Point silt, and at the type locality (Timms Point), the exposed thickness of these three units is "30 to 80 feet, but the maximum computed thickness is about 120 feet" according to Woodring, Bramlette, and Kew (1946).

Geologists and paleontologists agree that the Timms Point silt was deposited after the Lomita marl and before the San Pedro sand. Although it generally has been accepted that the Lomita marl is early Pleistocene in age, my otolith investigations and recent work of others on molluscan assemblages (Kanakoff and McLean, 1966; Kanakoff, pers. commun.; and S. S. Berry, pers. commun.) suggest the Lomita marl is probably the youngest marine Pliocene

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TABLE 1

Fish Remains Found in the San Pedro, California, Timms Point Pleistocene

Scientific name	Common name	Type and number of remains			
		otoliths	teeth	vertebrae	other
ELASMOBRANCHS					
<i>Carcharodon carcharias</i>	white shark		2		
<i>Galeorhinus zyopterus</i>	soupfin shark		9		
<i>Heterodontus francisci</i>	horn shark		1		
<i>Isurus oxyrinchus</i>	mako		7		
<i>Prionace glauca</i> ¹	blue shark		1		
<i>Raja</i> spp.	skates		16		1*
<i>Squalus acanthias</i>	spiny dogfish		19		
<i>Squatina californica</i> ¹	Pacific angel shark				1†
<i>Triakis semifasciata</i>	leopard shark		1		
TELEOSTS					
<i>Ammodytes hexapterus</i>	sandlance		8		
<i>Artedius notospilotus</i>	bonehead sculpin		6		
<i>Atheresthes stomias</i>	arrowtooth flounder		1		
<i>Atherinops affinis</i>	topsmelt		2		
<i>Brosomphycis marginata</i>	red brotula		15		
<i>Ceratoscopelus townsendi</i>	dogtooth lightfish		1		
<i>Chitonotus pugetensis</i>	roughback sculpin		7		
<i>Citharichthys sordidus</i>	Pacific sanddab		16		
<i>Citharichthys stigmaeus</i>	speckled sanddab		25		
<i>Citharichthys xanthostigma</i>	longfin sanddab		22		
<i>Citharichthys</i> spp.	sanddabs		267		
<i>Clupea pallasii</i>	Pacific herring		5		
<i>Coryphopterus nicholsi</i>	bluespot goby		276		
cottids	sculpins		419		
<i>Cymatogaster aggregata</i>	shiner perch		114		
<i>Diaphus theta</i>	California headlightfish		10		
<i>Electrona rissoi</i>	chubby flashlightfish		8		
embiotocids ¹	surfperches		7		
<i>Engraulis mordax</i>	northern anchovy		4		
<i>Enophrys taurina</i>	bull sculpin		6		
<i>Genyonemus lineatus</i>	white croaker		8		
<i>Glyptocephalus zachirus</i>	rex sole		45		
<i>Icelinus burchami</i>	dusky sculpin		1		
<i>Icelinus filamentosus</i>	threadfin sculpin		7		
<i>Icelinus fimbriatus</i>	fringed sculpin		7		
<i>Icelinus quadriseriatus</i>	yellowchin sculpin		43		
<i>Icelinus tenuis</i>	spotfin sculpin		11		
<i>Lampadena urophaos</i>	sunbeam lampfish		1		
<i>Leptocottus armatus</i>	Pacific staghorn sculpin		3		
<i>Lethops connectens</i>	halfblind goby		78		
<i>Lycodopsis pacifica</i>	blackbelly eelpout		34		
<i>Lyconectes aleutensis</i>	dwarf wrymouth		25		

TABLE 1 (continued)

Fish Remains Found in the San Pedro, California, Timms Point Pleistocene

Scientific name	Common name	Type and number of remains			
		otoliths	teeth	vertebrae	other
<i>Lyopsetta exilis</i>	slender sole	219			
<i>Malacocottus zonurus</i>	blackfin sculpin	4			
<i>Melamphaes lugubris</i>	black bigscale	1			
<i>Merluccius productus</i>	Pacific hake	22			
<i>Microgadus proximus</i>	Pacific tomcod	11			
<i>Microstomus pacificus</i>	Dover sole	1			
<i>Otophidium taylori</i>	spotted cusk-eel	113			
<i>Oxyjulis californica</i>	señorita	2			
<i>Parophrys vetulus</i>	English sole	24			
<i>Pimelometopon pulchrum</i>	California sheephead		4		
<i>Porichthys notatus</i>	plainfin midshipman	101			
<i>Protomyctophum crockeri</i>	California flashlightfish	8			
<i>Radulinus asprellus</i>	slim sculpin	81			
<i>Scopelogadus bispinosus</i>	twospine bigscale	1			
<i>Sebastodes goodei</i>	chilipepper	1			
<i>Sebastodes hopkinsi</i>	squarespot rockfish	1			
<i>Sebastodes rosaceus</i>	rosy rockfish	1			
<i>Sebastodes</i> spp.	rockfish	464			
<i>Sebastolobus</i> sp.	channel rockfish	3			
<i>Seriphus politus</i>	queenfish	8			
<i>Stenobranchius leucopsarus</i>	northern lampfish	35			
<i>Tarletonbeania crenularis</i>	blue lanternfish	10			
<i>Theragra chalcogramma</i>	walleye-pollack	4			
<i>Trachurus symmetricus</i>	Pacific jackmackerel	1			
<i>Xeneretmus</i> cf. <i>latifrons</i>	blackedge poacher	2			
	unidentified teleosts	2	8	121	1**

*skate "wing" spine

**fin ray spine

†dermal denticle

‡in William Zinsmeister collection

in the Los Angeles area. This being the case, the Timms Point silt would be the oldest Pleistocene of the region.

No age estimate is available for the Timms Point silt, but a potassium-argon analysis of glauconite from the Lomita marl has yielded an estimate of 3.04 million years before the present (B.P.) for that unit (Obradovich, 1965). Fanale and Schaeffer (1965), utilizing helium-uranium and ionium radiometric ratios and measurements, estimated the age of the 1200-foot terrace of the Palos Verdes hills as $>300,000$ years (5 samples) and $325,000 \pm 60,000$ years (1 sample). This marine terrace is the oldest late Pleistocene of southern California, having been laid down after the San Pedro sand. Unfortunately, because Fanale and Schaeffer (1965) report that the Lomita marl is

intermediate in age between the 70- and 1,200-foot terraces, considerable doubt is cast upon the validity of their techniques for determining geochronology.

Valentine (1961), using data for molluscan assemblages, speculated that the Timms Point silt was deposited at depths between "about 25 and 100 fathoms, and waters at those depths were cooler in some season [sic] at least than at present." The fish remains that I identified (Table 1) lend support to these theories of depth and temperature. In all, 2,601 otoliths, 121 vertebrae, 68 teeth (56 from elasmobranchs and 12 from teleosts), 2 elasmobranch dermal denticles, and 1 fin spine were recovered from 1,000 pounds or more of fossiliferous matrix excavated from this site. These items represent a minimum of 53 species of bony fishes (teleosts) and 9 of sharks, skates, and rays.

Previously, only Bagg (1912) had noted teleost remains from the Timms Point silt, but his report, comprising a single plate (Pl. 28 a-e) illustrating five assorted sagittae, fails to identify them except as otoliths. Unfortunately, two of these (figures c and e) show outer faces, so they are identifiable only as cottids (Cottidae); however, his figures a, b, and d are of *Tarletonbeania crenularis*, *Sebastodes* sp., and *Cymatogaster aggregata*, respectively. Clark (1931) listed shark teeth (3 or fewer specimens at 1 of 15 stations) in one of his tables. He questionably identified these as "*Galeus zyopterus*." Nine of the 56 elasmobranch teeth that I identified (Table 1) were from this species (*Galeorhinus zyopterus*).

Most of the Timms Point silt exposures mentioned by Arnold (1903), Clark (1931), and Woodring *et al.* (1946) have long since disappeared, and at the present rate of human encroachment, another decade could see the last surface outcrop of this important horizon covered by a building, highway, retaining wall, or some similar "mark of progress." Thus, unless some concerted effort is made to salvage additional fossiliferous Timms Point silt in the near future, the small handful of otoliths, teeth and other remains reported here may be our only record of the fish fauna during the million years or so of geologic history required to deposit this material. Except for a small amount of material in the Zinsmeister collection, the otoliths and other fish remains reported upon here are deposited in the Los Angeles County Museum of Natural History; the figured specimens have been curated separately.

SYSTEMATIC ACCOUNT

Heterodontidae—horn sharks

Heterodontus francisci (Girard)—horn shark

Horn sharks are abundant in rocky subtidal areas between about Morro Bay, California, and Magdalena Bay, Baja California. They seldom move about during daylight hours, but at night they can be found foraging the bottom for food, primarily crustaceans. During their nocturnal feeding, they occasionally stray into areas of sandy or sandy-mud bottoms. They are reported to

attain a length of about 4 feet, but the largest I have seen was 3 feet 2½ inches long and weighed 22 pounds. Horn shark teeth have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1966, and unpublished data; Kanakoff, 1956).

Material: 1 tooth.

Isuridae—mako sharks

Carcharodon carcharias (Linnaeus)—white shark

The white shark, an inhabitant of temperate and subtropical waters throughout the world, ranges from Alaska to Mazatlan, Mexico, in the eastern north Pacific (Kato, 1965). A large individual for our coast would be 12 to 15 feet long, although white sharks are reported (unreliably) to attain 35 feet. This species probably is responsible for most of California's unprovoked attacks on swimmers and bathers, usually occurring in relatively shallow water near shore. White shark teeth have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1964, and unpublished data; Fitch and Reimer, 1967; Kanakoff, 1956).

Material: 2 teeth.

Isurus oxyrinchus Rafinesque—mako

This world-ranging species is fairly common in our coastal waters between about San Francisco and Magdalena Bay, Baja California. An 11-footer from Santa Catalina Island, California, is the largest authentic record for the species, but the usual mako in the eastern north Pacific is shorter than 8 feet. Mako remains, primarily teeth, have been found in numerous southern California Pliocene and Pleistocene deposits, sometimes reported as *I. glaucus* (Fitch, 1964, 1967, and unpublished data; Kanakoff, 1956).

Material: 7 teeth.

Triakidae—smoothhounds

Triakis semifasciata Girard—leopard shark

Leopard sharks have been caught at many localities between Oregon and Mazatlan, Mexico. They usually frequent shallow areas where the bottom is sandy, but they also abound in rocky areas, especially around southern California's coastal islands. Females grow larger than males and may reach lengths of 7 feet, but a 5-foot, 35-pounder can be considered quite large. Leopard shark remains have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967 and unpublished data; Fitch and Reimer, 1967).

Material: 1 tooth.

Carcharhinidae—requiem sharks

Galeorhinus zyopterus Jordan and Gilbert—soupfin shark

The soupfin shark ranges from northern British Columbia to about

Magdalena Bay, but is not abundant at the more southerly latitudes. Females occur principally south of Point Conception, usually at depths of 100 to 600 feet or more. A 6½-foot female may weigh as much as 100 pounds, but 50- to 70-pounders are most often encountered. Soupfin shark remains, mostly teeth, have been reported from the Timms Point silt (Clark, 1931), and have been found in numerous other southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967; Kanakoff, 1956).

Material: 9 teeth.

Prionace glauca (Linnaeus)—blue shark

The blue shark is a pelagic species occurring in tropical, subtropical, and warm temperate areas of all world seas. Along the southern California coast they are extremely abundant during summer months, and they almost invariably are males. Twelve-footers have been caught off California (close to record size for the species), but our usual blue shark will not exceed 6 feet and 50 pounds. Blue shark remains are not abundant in fossil deposits, being known from only a few other localities (Fitch, unpublished data).

Material: 1 tooth in the Zinsmeister collection.

Squalidae—dogfish sharks

Squalus acanthias Linnaeus—spiny dogfish

The spiny dogfish abounds in the north Pacific Ocean (eastern and western), ranging south on our coast to Sebastian Viscaïno Bay, Baja California. Females attain larger sizes than males, and are reported to reach 5 feet, but a 4-footer is rare. Trawling off southern California yields the best spiny dogfish catches in 100 to 250 feet of water, but they have been caught as deep as 1,200 feet. Remains of *Squalus acanthias* have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967 and unpublished data).

Material: 19 teeth.

Squatinidae—angel sharks

Squatina californica Ayres—Pacific angel shark

Although the Pacific angel shark ranges from southern Alaska into the Gulf of California, it is not abundant north of Point Conception nor south of Magdalena Bay. They seem to prefer sandy or sandy mud bottoms at depths of 50 to 70 feet, but many are taken or seen in 6 to 8 feet of water and others in 150 feet or deeper. A 44-inch female, the largest I have seen, weighed 31 pounds. *Squatina* remains have been found in many Pliocene and Pleistocene deposits in southern California (Fitch, 1964, 1967, and unpublished data).

Material: 1 dermal denticle in the Zinsmeister collection.

Rajidae—skates

Raja spp.—skates, species undetermined

There do not appear to be any foolproof tooth characters for distinguishing the six species of skates that occur off California. At various times, one or more of these six skates can be captured at any depth from the shallow subtidal to several thousand feet. Four of the species (*R. inornata*, *R. stellulata*, *R. trachura*, and *R. kincaidi*) are “small” forms which probably never exceed lengths of 2½ feet (including tail) as adults. *R. rhina* is reported to attain 4 to 5 feet, and *R. binoculata* may reach 8 feet and exceed 150 pounds. Skate remains, mostly teeth and “wing” spines, have been found in numerous southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data).

Material: 16 teeth and 1 wing spine.

Clupeidae—herrings

Clupea pallasii Valenciennes—Pacific herring

The Pacific herring, a schooling fish, ranges throughout the north Pacific Ocean (eastern and western), but because of pollution and bay development, herring seldom are observed south of Point Conception at present, although they were abundant in San Diego Bay three decades ago. Pacific herring are said to attain lengths of 18 inches, but a 12- to 14-inch individual is considered quite large. Pacific herring otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967 and unpublished data). The sagittae of a large, adult Pacific herring will exceed 5.0 mm in length.

Material: 5 otoliths from 2.9 to longer than 3.3 mm (Fig. 1a).

Engraulidae—anchovies

Engraulis mordax Girard—northern anchovy

The northern anchovy, a schooling fish, ranges from British Columbia to Magdalena Bay, and offshore for more than 100 miles. It is reported to attain a length of 9 inches, but the largest I have seen was an 8-inch fish that weighed 2 ounces. Otoliths of *E. mordax* have been found in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967). The sagittae of a large, adult northern anchovy will exceed 4.5 mm in length.

Material: 4 otoliths from 2.8 to 4.1 mm long (Fig. 1b).

Myctophidae—lanternfishes

Ceratoscopelus townsendi (Eigenmann and Eigenmann)—dogtooth lampfish

This little fish (attaining perhaps 4 inches when fully grown) is widely

distributed in tropical and temperate waters of the Pacific, Indian, and Atlantic Oceans. Along our coast, *C. townsendi* ranges from north of San Francisco to Magdalena Bay, Baja California, at least. Except at night, they seldom approach within 600 feet of the surface. Their otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult *C. townsendi* will exceed 3.0 mm in length. *Material*: 1 otolith 2.6 mm long (Fig. 1c).

Diaphus theta Eigenmann and Eigenmann—California headlightfish

Diaphus theta ranges from the Gulf of Alaska to Cedros Island, Baja California, and offshore for several hundred miles, at least. They are reported to attain a length of 4½ inches (Clemens and Wilby, 1961), but in the central and southern parts of their range a 3½-inch individual is a rarity. At night, *D. theta*, along with other creatures that make up deep scattering layers, migrates upward and has been captured within 30 feet of the surface. During daylight hours it usually is found at depths of 1,000 feet or more. Otoliths of *D. theta* have been found in several southern California Pliocene and Pleistocene deposits, more than 400 having been recovered from a San Pedro, California (Lomita marl) deposit (Fitch, unpublished data). The sagittae of a large, adult *D. theta* will exceed 3.0 mm in length.

Material: 10 otoliths from 1.0 to 3.1 mm long (Fig. 1d).

Electrona rissoi (Cocco)—chubby flashlightfish

The chubby flashlightfish apparently lives in the scattering layers 1,000 feet or more beneath the surface during daylight hours but nearer the surface at night. It is rarely caught off California today, but may be abundant in other areas. In the eastern Pacific, it ranges from about Point Conception to Magdalena Bay, at least. The validity of the name *rissoi* is questionable for the form in the eastern north Pacific, but the otoliths found in this deposit match perfectly, in morphometry but not necessarily in size, the otoliths removed from a 1½-inch-long individual caught off our coast (the species attains 2¾ inches, at least). Otoliths of *E. rissoi* have been found in small numbers in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data; Fitch and Reimer, 1967). The sagittae of a large, adult *E. rissoi* will exceed 3.5 mm in length.

Material: 8 otoliths from 2.3 to 4.1 mm long (Fig. 1e).

Lampadena urophaos Paxton—sunbeam lampfish

L. urophaos ranges from about mid-Oregon to Magdalena Bay and offshore for a considerable distance. At night, it sometimes migrates to within about 150 feet of the surface, but during daylight hours it seldom is captured shallower than about 800 feet. This species may attain 5 inches when full grown. The otoliths of *L. urophaos* are larger than those of any other myctophid I have examined. (My comparative collection contains sagittae from more

than 100 myctophid species representing all but one of the recognized genera.) *L. urophaos* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult *L. urophaos* will exceed 7.5 mm in length.

Material: 1 incomplete otolith 4.0 mm long (Fig. 1i).

Protomyctophum crockeri (Bolin)—California flashlightfish

P. crockeri is distributed throughout the western and eastern north Pacific Ocean (apparently discontinuously), ranging on our coast from off Puget Sound to Cape San Lucas and offshore for a considerable distance. A large individual might measure 3 inches in total length, but few exceeding 2½ inches are caught. As with other myctophids, this species also approaches the surface at night, but not to the same extent, preferring to remain 500 feet deep or deeper. Otoliths of *P. crockeri* have been found in several southern California Pliocene and Pleistocene deposits, nearly 200 having been recovered from the Lomita marl (Pliocene) at San Pedro, California (Fitch, unpublished data). The sagittae of a large, adult *P. crockeri* will exceed 2.5 mm in length.

Material: 8 otoliths from 1.2 to 2.4 mm long (Fig. 1f).

Stenobranchius leucopsarus (Eigenmann and Eigenmann)—northern lampfish

S. leucopsarus is one of the most abundantly captured myctophids off California. It ranges from the Bering Sea to about Cedros Island and offshore for a considerable distance. At night it sometimes approaches to within 150 feet of the surface, returning to 750 feet or deeper during daylight hours. A large individual might measure 5 inches and weigh one-third of an ounce. Otoliths of *S. leucopsarus* have been found in many southern California Pliocene and Pleistocene deposits, more than 1,000 having been recovered from a San Pedro, California, (Lomita marl) deposit (Fitch, 1966, 1967, and unpublished data). The sagittae of a large, adult northern lampfish will exceed 1.8 mm in length.

Material: 35 otoliths from 0.8 to 2.0 mm long (Fig. 1g).

Tarletonbeania crenularis (Jordan and Gilbert)—blue lanternfish

The blue lanternfish ranges on our coast from northern Alaska to San Diego and offshore for a considerable distance. This species often migrates to the surface of the ocean at night, but during daylight hours it apparently prefers depths of 600 feet or more. It is reported to attain a length of 5½ inches, but off California a 4½-inch fish is unusual. Otoliths of *T. crenularis* have been found in several southern California Pliocene and Pleistocene deposits, more than 300 having been recovered from the Lomita marl (Pliocene) at San Pedro (Fitch, unpublished data). Bagg (1912) illustrated a sagitta of *T. crenularis*, but did not identify it beyond calling it an otolith. The sagittae of a large, adult blue lanternfish will exceed 1.8 mm in length.

Material: 10 otoliths from 1.2 to 2.0 mm long (Fig. 1h).

Merlucciidae—hakes

Merluccius productus (Ayres)—Pacific hake

Pacific hake range from Alaska to the southern tip of Baja California, and offshore for 350 miles or more. Sometimes they are found in shallow water near shore, but mostly they travel in dense schools near the bottom where the water is deeper than 600 feet. They are said to reach lengths of 3 feet, but a 30-inch fish is rare; a 26-inch female weighed slightly more than 4 pounds. *M. productus* otoliths have been found in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, and unpublished data; Fitch and Reimer, 1967). The sagittae of a large, adult Pacific hake will exceed 30.0 mm in length.

Material: 22 otoliths from about 7.5 to longer than 26.0 mm (Fig. 1j).

Gadidae—cods

Theragra chalcogramma (Pallas)—walleye-pollack

The walleye-pollack inhabits bottom waters of the north Pacific (western and eastern), ranging south to about Monterey Bay on our coast. It is reported to reach a length of 3 feet and a weight of 7 or 8 pounds, but maximum sizes need authentication. Sagittae of *T. chalcogramma* have not been recovered from any fossil deposit except the Timms Point Pleistocene (this report), and a late Pleistocene deposit at San Pedro. The sagittae of a large, adult walleye-pollack will exceed 20.0 mm in length.

Material: 4 otoliths from 9.8 to 18.2 mm long (Fig. 1k).

Microgadus proximus (Girard)—Pacific tomcod

The Pacific tomcod ranges from Alaska to about Morro Bay, California, usually at depths of 200 feet or more, but sometimes in shallow water just outside the surf zone. A large individual might be 12 inches long but no weights are available for such a fish; a 10¼-inch female weighed just under 6 ounces. *M. proximus* otoliths are abundant in some southern California Pliocene deposits, and in the Pleistocene of northern California and Oregon (Fitch, unpublished data). The sagittae of a large, adult Pacific tomcod will exceed 14.0 mm in length.

Material: 11 otoliths 3.4 to larger than 6.0 mm (not figured).

Melamphaidae—big scales

Melamphaes lugubris Gilbert—black bigscale

M. lugubris ranges from the Bering Sea to Cedros Island, Baja California, and offshore for a considerable distance. Although young individuals usually inhabit shallower depths and more-northerly waters than adults, black big-scales are most often captured 150 to 1,500 feet beneath the surface in quite deep water. They are reported to attain lengths of about 4½ inches. Otoliths of

M. lugubris have been found in only one other California deposit (Lomita marl Pliocene, San Pedro), but even there they are extremely rare (Fitch, unpublished data). The sagittae of a large, adult black bigscale will exceed 5.0 mm in length.

Material: 1 otolith 1.3 mm long (Fig. 1 l).

Scopelogadus bispinosus (Gilbert)—twospine bigscale

S. bispinosus ranges from about latitude 40° N. to latitude 20° S., and offshore across the Pacific. Young and half-grown individuals have been captured 400 feet beneath the surface and deeper, but adults seldom are captured within about 1,300 feet of the surface. The females attain larger sizes than males, reaching perhaps 4½ inches. Otoliths of *S. bispinosus* have been found in only one other California deposit (Lomita marl Pliocene, San Pedro), but even there they are very rare (Fitch, unpublished data). The sagittae of a large, adult twospine bigscale will exceed 2.0 mm in length.

Material: 1 otolith 2.0 mm long (Fig. 1 m).

Bothidae—lefteyed flounders

Citharichthys sordidus (Girard)—Pacific sanddab

Pacific sanddabs are reported to range from southern Alaska to about Magdalena Bay, but their occurrence in central and southern Baja California needs to be verified. The maximum length and weight attributed to *C. sordidus* (16 inches and 2 pounds) also needs verifying. *Citharichthys* otoliths are abundant in most southern California Pliocene and Pleistocene deposits, and many of these are identifiable as *C. sordidus* (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967). The sagittae of a large, adult Pacific sanddab will exceed 8.0 mm in length.

Material: 16 otoliths from 4.2 to 6.7 mm long (Fig. 1 n).

Citharichthys stigmaeus Jordan and Gilbert—speckled sanddab

Speckled sanddabs range along the coast from southeastern Alaska to Sebastian Viscaïno Bay, Baja California, usually at depths shallower than 200 feet. A possible record-sized male just over 5½ inches long weighed just over 1 ounce. *C. stigmaeus* otoliths are abundant in most southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967). The sagittae from a large, adult speckled sanddab will exceed 3.5 mm in length.

Material: 25 otoliths from 1.7 to 2.9 mm long (Fig. 1 o).

Citharichthys xanhostigma Gilbert—longfin sanddab

The longfin sanddab ranges from Monterey Bay, California, to about Magdalena Bay, usually in water shallower than 500 feet. It probably attains a maximum size somewhat in excess of 10 inches and 8 ounces. *C. xanhostigma*

otoliths are fairly abundant in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult longfin sanddab will exceed 7.0 mm in length.

Material: 22 otoliths from 3.0 to 7.3 mm long (Fig. 1p).

Citharichthys spp.—sanddabs, species undetermined

The otoliths of all three species of *Citharichthys* known to California are easily distinguished if they are in good condition, but most fossil sanddab otoliths are either worn or fragmented, making specific identification difficult if not impossible. Probably all three species are represented among the unidentified sanddab otoliths found in this deposit.

Material: 267 otoliths.

Pleuronectidae—righteyed flounders

Atheresthes stomias (Jordan and Gilbert)—arrowtooth flounder

The arrowtooth flounder ranges from the Bering Sea to Morro Bay, California, sometimes as shallow as 60 feet and other times as deep as 2,400. They are known to attain a length of 32¼ inches and a weight of 10 pounds—a 26-inch female weighed 6¼ pounds. *A. stomias* otoliths have been found in only one other fossil deposit (Lomita marl Pliocene, San Pedro), but even in that deposit they are rare (Fitch, unpublished data). The sagittae of a large, adult arrowtooth flounder will exceed 13.0 mm in length.

Material: 1 otolith 9.0 mm long (Fig. 1q).

Glyptocephalus zachirus Lockington—rex sole

The rex sole ranges from the Bering Sea to Ensenada, Baja California (at least), in from 25 to over 2,000 feet of water. They are reported to attain a maximum size of 22 inches and about 3 pounds. Rex sole otoliths are abundant in many southern California Pliocene and Pleistocene deposits (Fitch, 1967), more than 700 having been recovered from the Lomita marl Pliocene at San Pedro (Fitch, unpublished data). The sagittae of a large, adult rex sole will exceed 7.0 mm in length.

Material: 45 otoliths from 1.2 to 5.3 mm long (Fig. 1r).

Lyopsetta exilis (Jordan and Gilbert)—slender sole

The slender sole ranges from southeastern Alaska to Cedros Island, usually in depths of 400 to 800 feet, but sometimes as shallow as 120 feet or as deep as 1,700. A large individual might exceed 12 inches in length, but would not weigh more than ¼ pound. *L. exilis* otoliths have been found in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967), more than 2,000 having been recovered from the Lomita marl Pliocene at San Pedro (Fitch, unpublished data). The sagittae of a large, adult slender sole will exceed 5.5 mm in length.

Material: 219 otoliths from 1.0 to 5.0 mm long (Fig. 1s).

Microstomus pacificus (Lockington)—Dover sole

The Dover sole ranges from northwestern Alaska to Ensenada (at least), usually at depths of 400 to 1,200 feet, but sometimes as shallow as 100 feet or as deep as 2,400. They are said to attain a maximum size of 30 inches and 10 pounds, but individuals exceeding 5 pounds are rarely seen. I have not found otoliths of *M. pacificus* in any other fossil deposit. The sagittae of a large, adult Dover sole will exceed 8.0 mm in length.

Material: 1 otolith 2.8 mm long (Fig. 1u).

Parophrys vetulus Girard—English sole

The English sole ranges from northwestern Alaska to Cedros Island, migrating inshore to spawn but living in deep water (to 1,000 feet) most of the remaining time. They attain a maximum size of 21 inches and about 3 pounds, but individuals exceeding 2 pounds are rarely seen. The otoliths of *P. vetulus* are difficult to distinguish from those of two other California flatfishes, *Eopsetta jordani* and *Lepidopsetta bilineata*, unless they are in perfect or near-perfect condition. Most of the Timms Point otoliths that I identified as *Parophrys* were in relatively poor condition. The sagittae of a large, adult English sole will exceed 9.0 mm in length.

Material: 24 otoliths from 1.6 to longer than 6.5 mm (Fig. 1t).

Atherinidae—silversides

Atherinops affinis (Ayres)—topsmelt

Topsmelt range from the Straits of Juan de Fuca to and into the Gulf of California. Various subspecies inhabit bays, kelp beds, and offshore island areas where they live at or near the surface. A 14½-inch female weighing slightly less than 12 ounces appears to be a record size. *A. affinis* otoliths have been found in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data). The sagittae of a large, adult topsmelt will exceed 5.0 mm in length.

Material: 2 otoliths from 2.1 to 4.4 mm long (Fig. 1v).

Carangidae—jacks

Trachurus symmetricus (Ayres)—Pacific jackmackerel

The Pacific jackmackerel, a schooling fish, is perhaps one of the three or four most abundant species off our coast, ranging from British Columbia to Cape San Lucas and offshore for several hundred miles. Jackmackerel are known to attain a length of 30 inches and a weight of 5 pounds, but most individuals in the commercial catch are smaller than 15 inches and 1 pound. *T. symmetricus* otoliths have been found in several southern California Pliocene and Pleistocene deposits, but they are not abundant in any of them.

(Fitch, 1966, 1967, and unpublished data). The sagittae of a large, adult Pacific jackmackerel will exceed 10.0 mm in length.

Material: 1 otolith 4.3 mm long (Fig. 1w).

Sciaenidae—croakers

Genyonemus lineatus (Ayres)—white croaker

The white croaker ranges from Vancouver Island to Magdalena Bay, abounding in almost every type of habitat from the intertidal into depths of 600 feet. A near-record 14½-inch fish weighed 1.4 pounds. *G. lineatus* otoliths often are the most abundant fish remains in southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967; Kanakoff, 1956), comprising 6,409 of the more than 11,000 otoliths recovered from the San Diego formation (Pliocene) near Imperial Beach (Fitch, unpublished data). The sagittae of a large, adult white croaker will exceed 12.5 mm in length.

Material: 8 otoliths from 4.5 to 7.0 mm long (Fig. 1x).

Seriphus politus Ayres—queenfish

The queenfish ranges from Yaquina Bay, Oregon, to San Juanico Bay, Baja California, living in much the same habitat as the white croaker. A near-record 12-inch female weighed just over 10 ounces. *S. politus* otoliths have been found in many southern California Pliocene and Pleistocene deposits, often comprising a major portion of the total fish remains recovered (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967; Kanakoff, 1956). The sagittae of a large, adult queenfish will exceed 10.0 mm in length.

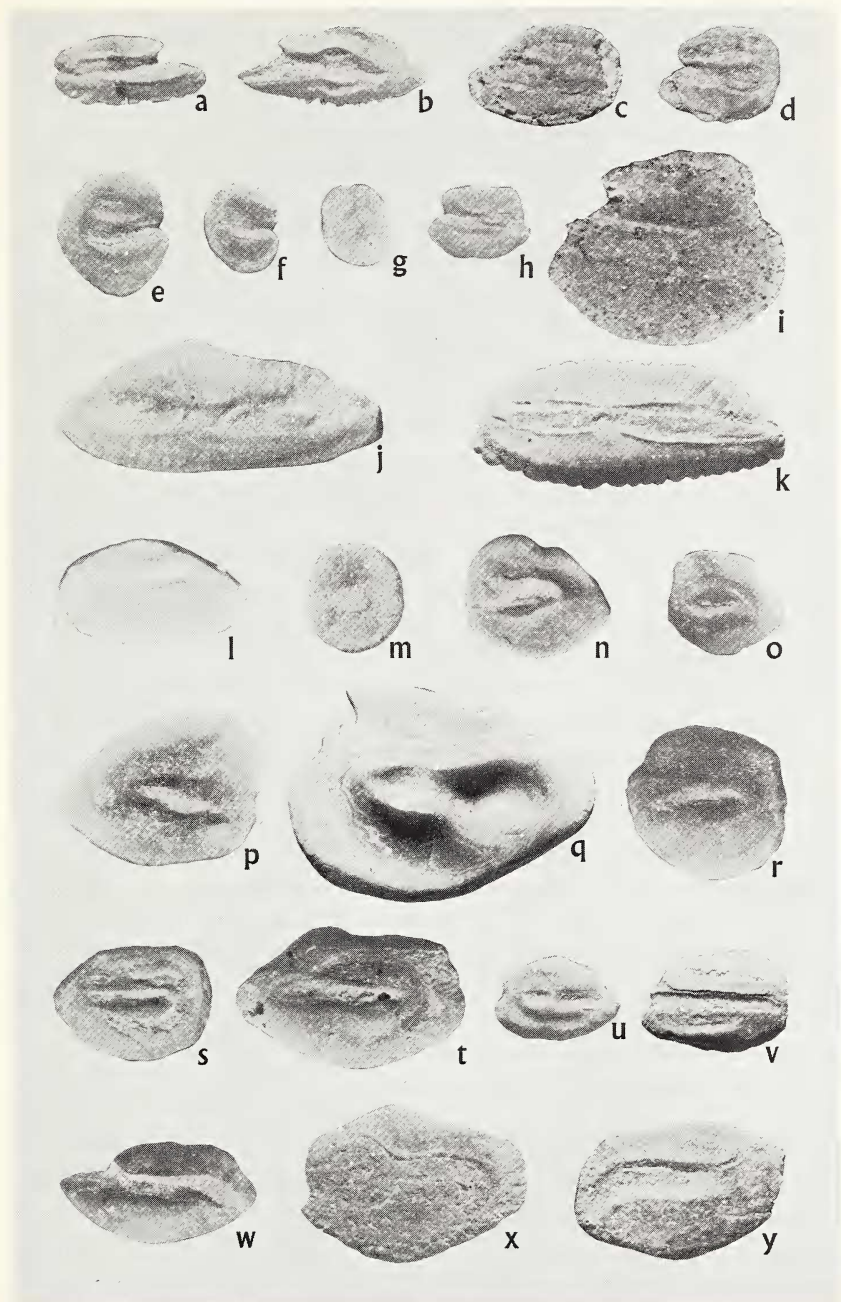
Material: 8 otoliths from 3.0 to 6.6 mm long (Fig. 1y).

Embiotocidae—surfperches

Cymatogaster aggregata Gibbons—shiner perch

The shiner perch ranges from Port Wrangel, Alaska, to Santo Tomas Point, Baja California, being restricted to the mainland coast, primarily in

Figure 1. Teleost sagittae found in Timms Point silt at San Pedro, California. Lengths (in mm) are given for each otolith, and notations are made regarding its position in the skull (left or right), and condition if imperfect. a. *Clupea pallasii*, 3.3, l; b. *Engraulis mordax*, 4.1, r; c. *Ceratoscopelus townsendi*, 2.6, r, badly worn; d. *Diaphus theta*, 2.7, r; e. *Electrona rissoi*, 3.4, l; f. *Protomyctophum crockeri*, 1.7, l; g. *Stenobranchius leucopsarus*, 1.6, l; h. *Tarletonbeania crenularis*, 2.0, r; i. *Lampadena urophaos*, 4.0, r, anterior end missing; j. *Merluccius productus*, 10.2, r, posterior tip missing; k. *Theragra chalcogramma*, 9.8, r; l. *Melamphaes lugubris*, 1.3, l, badly eroded; m. *Scopelogadus bispinosus*, 2.0, r; n. *Citharichthys sordidus*, 4.5, l; o. *C. stigmatæus*, 2.7, l; p. *C. xanthostigma*, 6.3, r; q. *Atheresthes stomias*, 9.0, l, badly eroded; r. *Glyptocephalus zachirus*, 3.3, r; s. *Lyopsetta exilis*, 3.6, r; t. *Parophrys vetulus*, 5.0, r; u. *Microstomus pacificus*, 2.8, l; v. *Atherinops affinis*, 4.4, r, anterior tip missing; w. *Trachurus symmetricus*, 4.3, r, badly worn; x. *Genyonemus lineatus*, 5.0, r, badly worn; y. *Seriphus politus*, 6.6, l, badly worn. Photographs by Jack W. Schott.



depths shallower than 50 feet but sometimes caught as deep as 400. A record-sized pregnant female weighed just under 3 ounces. *C. aggregata* otoliths are abundant in most southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, and unpublished data; Fitch and Reimer, 1967), comprising 1,129 of the more than 2,700 otoliths recovered from a San Pedro Pleistocene deposit (Miraflores Street: Fitch, 1967). Bagg (1912) illustrated a *C. aggregata* sagitta from Timms Point, but did not identify it except as an otolith. The sagittae of a large, adult shiner perch will exceed 6.5 mm in length.

Material: 114 otoliths from 2.2 to 6.8 mm long (Fig. 2a).

Embiotocidae—unidentified surfperches

Seven otolith fragments in the Zinsmeister collection could be identified as belonging to family Embiotocidae, but it was impossible to assign them to a genus or species.

Labridae—wrasses

Oxyjulis californica (Günther)—señorita

The señorita ranges from Natural Bridges State Park, California, to Cedros Island, inhabiting shallow areas of rocky substrate where kelp beds and other vegetation grow. A near-record 9-inch male speared at Dana Point in January 1965 weighed 4 ounces. Señorita otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967, and unpublished data). The sagittae of a large, adult señorita will exceed 3.5 mm in length.

Material: 2 otoliths 1.5 mm long (Fig. 2b).

Pimelometopon pulchrum (Ayres)—California sheephead

The California sheephead ranges from Monterey Bay to and into the Gulf of California. Throughout much of this area they abound in rocky areas, particularly where dense kelp beds grow. The male sheephead grows bigger and lives longer than the female. A record weight seems to be 36¼ pounds, but this fish was not measured. A 29-pound male was 32 inches long. *P. pulchrum* remains, primarily jaw and pharyngeal teeth, have been found in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, and unpublished data; Kanakoff, 1956).

Material: 3 jaw teeth, plus 1 pharyngeal clump in the Zinsmeister collection.

Scorpaenidae—rockfishes

Sebastes goodei Eigenmann and Eigenmann—chilipepper

The chilipepper ranges from Vancouver Island to Magdalena Bay, inhabiting depths of 350 to 1,080 feet when adult, but living in shallower water as a juvenile. A 20½-inch female (they are reported to attain 22 inches)

weighed 3 pounds 5 ounces. *S. goodei* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult chilipepper will exceed 17.0 mm in length. *Material*: 1 otolith 7.3 mm long (Fig. 2d).

Sebastes hopkinsi Cramer—squarespot rockfish

The squarespot rockfish ranges from Halfmoon Bay, California, to south of Ensenada, Baja California, usually in depths of 60 to 600 feet. They are reported to attain a size of 11 inches and about $\frac{1}{2}$ pound. An 8½-inch fish weighed just over 4 ounces and was found to be 5 years old. *S. hopkinsi* remains have not been identified from any other fossil deposit. The sagittae of a large, adult squarespot rockfish will exceed 10.0 mm in length.

Material: 1 otolith 4.5 mm long (Fig. 2c).

Sebastes rosaceus Jordan and Gilbert—rosy rockfish

The rosy rockfish ranges from Queen Charlotte Sound to Turtle Bay, Baja California, usually in 60 to 450 feet of water. A 10-inch female (the species attains a maximum of 12¾ inches) weighed slightly less than $\frac{1}{2}$ pound. I have not identified *S. rosaceus* remains from any other fossil deposit. The sagittae of a large, adult rosy rockfish will exceed 13.0 mm in length.

Material: 1 otolith 8.7 mm long (Fig. 2e).

Sebastes spp.—rockfishes, species undetermined

The otoliths of most of the 52 species of *Sebastes* inhabiting the waters of California can be distinguished one from the other if they are from adult fish, and if they are not badly worn or broken. Such characters as length and shape of rostrum (if present), configuration of posterior end, presence or absence of marginal frills, angle of posterior taper, depth of sulcus, and number of growth zones (annuli) for otolith length are helpful for identifying sagittae of the various species or species-complexes. Unfortunately, very few fossil rockfish otoliths are well enough preserved to be identified to species. Bagg (1912) illustrated a *Sebastes* sagitta from this deposit but did not identify it except as an otolith. Kanakoff (1956) reported *Sebastes* otoliths from a Newport Beach Pleistocene deposit.

Material: 464 otoliths, apparently representing more than five species, mostly from juveniles.

Sebastes sp.—channel rockfish

Two species of *Sebastes* inhabit the waters off California: *S. alascanus*, which attains nearly 30 inches, lives in shallower depths (to 2,000 feet) than the smaller (15 inches maximum) *S. altivelis*, which has been caught as deep as 2,500 feet. *Sebastes* otoliths are readily distinguished from those of *Sebastes*, but I have not found any characters (except size) to distinguish sagittae of *S. alascanus* from those of *S. altivelis*. Otoliths from a large (12-

inch) *S. altivelis* are about 10.0 mm long, whereas those from a large (21-inch, and 4¼-pound) *S. alascanus* are about 16.0 mm—both fish appeared to be roughly the same age.

Material: 3 otoliths from 7.0 to 9.0 mm long, the largest (Fig. 2f) probably from the shortspine channel rockfish, *S. alascanus* Bean.

Cottidae—sculpins

Artedius notospilotus Girard—bonehead sculpin

The bonehead sculpin ranges from Puget Sound, Washington, to Cape Colnett, Baja California, being taken in the intertidal and in 180 feet at the other extreme. A record-sized female trawled off Anaheim Bay, California, in February 1957, was 8¼ inches long and weighed just over 6 ounces. *A. notospilotus* otoliths have been found in several southern California Pliocene and Pleistocene deposits, but they are never abundant (Fitch, unpublished data; Fitch and Reimer, 1967). The sagittae of a large, adult bonehead sculpin will exceed 6.0 mm in length.

Material: 6 otoliths from 3.5 to longer than 5.3 mm, the length of a fragmented one (Fig. 2g).

Chitonotus pugetensis (Steindachner)—roughback sculpin

The roughback sculpin ranges from northern British Columbia to Magdalena Bay, usually at depths of 100 to 300 feet. A 7-inch fish, about maximum for the species, weighed just under 3 ounces. *C. pugetensis* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1967, and unpublished data). The sagittae of a large, adult roughback sculpin will exceed 6.0 mm in length.

Material: 7 otoliths from 2.6 to 4.4 mm long (Fig. 2h).

Enophrys taurina Gilbert—bull sculpin

The bull sculpin ranges from Monterey Bay to Santa Catalina Island, California, in depths of 30 to 800 feet (usually 100 to 250). A 6-inch fish, about maximum for the species, will weigh about 3 ounces. *E. taurina* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967 and unpublished data). The sagittae of an adult bull sculpin will exceed 5.5 mm in length.

Material: 6 otoliths from 4.4 to 5.2 mm long (Fig. 2i).

Icelinus burchami Evermann and Goldsborough—dusky sculpin

The dusky sculpin ranges from Alaska (55° N) to Santa Catalina Island, California (at least). It has been captured at depths of 600 to 1,500 feet, but appears to be rare throughout its range. A 5½-inch fish, about maximum for the species, weighs just over 2 ounces. *I. burchami* sagittae bear no resemblance to those of any other *Icelinus* otolith in my collection (six species), in fact

they are so different, they suggest a generic affinity other than with *Icelinus*. The dusky sculpin apparently was much more abundant in the Pliocene than it now is—nearly 600 of its otoliths were recovered from the Lomita marl at San Pedro (Fitch, unpublished data). The sagittae of an adult dusky sculpin will exceed 5.0 mm in length.

Material: 1 otolith 3.9 mm long (Fig. 2j).

Icelinus filamentosus Gilbert—threadfin sculpin

The threadfin sculpin ranges from northern British Columbia to the vicinity of Ensenada, at least. It is abundant on a muddy or sandy mud bottom in 60 to about 1,200 feet of water. A near-record 10½-inch female weighed just under 7 ounces. Otoliths of *I. filamentosus* have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult threadfin sculpin will exceed 10.0 mm in length.

Material: 7 otoliths from 3.6 to 5.7 mm long (Fig. 2k).

Icelinus fimbriatus Gilbert—fringed sculpin

The fringed sculpin ranges from about San Francisco to San Diego, having been taken in 150 to nearly 1,000 feet of water. An 8-inch female (maximum for the species is reported as 9 inches) weighed exactly 3 ounces. *I. fimbriatus* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult fringed sculpin will exceed 7.5 mm in length.

Material: 7 otoliths from 3.5 to 5.2 mm long (Fig. 2n).

Icelinus quadriseriatus (Lockington)—yellowchin sculpin

The yellowchin sculpin is one of the most abundant members of the family in moderate depths (50 to 250 feet) between about Point Reyes, California, and Cape San Lucas, Baja California. A 3½-inch fish, the largest of nearly 10,000 examined, weighed slightly less than 1 ounce. *I. quadriseriatus* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1966, and unpublished data). The sagittae of a large, adult yellowchin sculpin will exceed 3.8 mm in length.

Material: 43 otoliths from 2.4 to 4.1 mm long (Fig. 2 l).

Icelinus tenuis Gilbert—spotfin sculpin

The spotfin sculpin ranges from Queen Charlotte Sound to Guadalupe Island, Baja California, usually in depths of 100 to 400 feet. At maximum length, perhaps 4½ inches, a female *I. tenuis* probably weighs less than 1 ounce, even when full of roe. Spotfin sculpin otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967, and un-

published data). The sagittae of a large, adult spotfin sculpin will exceed 4.5 mm in length.

Material: 11 otoliths from 2.5 to 4.0 mm long (Fig. 2m).

Leptocottus armatus Girard—Pacific staghorn sculpin

The Pacific staghorn sculpin ranges from northwestern Alaska to San Quintin Bay, Baja California, being especially abundant in shallow outer coast waters, and in bays and lagoons. A 10-inch female (2 inches short of the reported maximum) netted in 1958, weighed $\frac{1}{2}$ pound. *L. armatus* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967, and unpublished data; Kanakoff, 1956). The sagittae of an adult staghorn sculpin will exceed 9.0 mm in length.

Material: 3 otoliths from 4.2 to 5.8 mm long (2o).

Malacocottus zonurus Bean—blackfin sculpin

The blackfin sculpin ranges from the Gulf of Alaska to southern Washington, being relatively abundant in 90 to 500 feet. It is reported to attain 8 inches and $\frac{1}{3}$ pound, but no data are available for a record-sized fish. *M. zonurus* otoliths have been found in only one other southern California fossil deposit (Lomita marl Pliocene, San Pedro)—more than 650 having been recovered from a relatively small field sample (Fitch, unpublished data). The sagittae of an adult blackfin sculpin will exceed 9.0 mm in length.

Material: 4 otoliths from 6.5 to 8.0 mm long (Fig. 2p).

Radulinus asprellus Gilbert—slim sculpin

The slim sculpin ranges from Kodiak Island, Alaska, to about Ensenada, being fairly abundant in 150 to 600 feet of water. A $5\frac{1}{2}$ -inch fish (large for the species) weighed about 1 ounce. Otoliths of *R. asprellus* have been found in several southern California Pliocene and Pleistocene deposits, over 1,300 having been recovered from the Lomita marl Pliocene at San Pedro (Fitch, 1967, and unpublished data). The sagittae of a large, adult slim sculpin will exceed 4.0 mm in length.

Material: 81 otoliths from 2.5 to 4.3 mm long (Fig. 2q).

Cottidae—genera and species undetermined

Cottid otoliths are easy to identify to family, but if they are worn or broken it is nearly impossible to assign a generic (except for *Icelinus*) or specific name. Most of the cottid otoliths in this deposit were badly eroded (perhaps from digestive action by some predator), and even though the majority of these appeared to be *Icelinus*, I preferred to list them simply as "undetermined cottids" for ease in accounting. Bagg (1912) illustrated two cottid sagittae from this deposit but did not identify them except as otoliths.

Material: 419 otoliths

Agonidae—poachers

Xeneretmus cf. *latifrons* (Gilbert)—blackedge poacher

The sagittae of the four species of *Xeneretmus* known to California are impossible to distinguish one from the other unless they are in perfect or near-perfect condition, and even then the task is difficult. Two of the species are rare, deep-water forms (*X. ritteri* and *X. leiops*), but the other two, *X. triacanthus* and *X. latifrons* are relatively common in moderate depths. *X. latifrons* is by far the most abundant of the four, and on this basis alone, I have questionably assigned the poacher otoliths from this deposit. The blackedge poacher ranges from southern British Columbia to about Ensenada, usually in 300 to 900 feet of water. A 7½-inch individual, which is apparently maximum length for *X. latifrons*, weighed slightly less than 1 ounce. *Xeneretmus* otoliths have been found in only one other southern California fossil deposit: Lomita marl Pliocene, San Pedro (Fitch, unpublished data). The sagittae of a large, adult blackedge poacher will exceed 5.0 mm in length.

Material: 2 otoliths, only one measurable (3.4 mm long, Fig. 2r).

Gobiidae—gobies

Coryphopterus nicholsi (Bean)—bluespot goby

The bluespot goby ranges from British Columbia to San Martin Island, Baja California, typically from the shallow subtidal into 200 feet or more. The maximum size attained by the species is about 5 inches and 1 ounce. *C. nicholsi* otoliths have been found in many southern California Pliocene and Pleistocene deposits, over 1,700 having been recovered from the Lomita marl Pliocene at San Pedro (Fitch, 1967, and unpublished data). The sagittae of a large, adult bluespot goby will exceed 3.0 mm in length.

Material: 276 otoliths from 1.1 to 3.5 mm long (Fig. 2s).

Lethops connectens Hubbs—halfblind goby

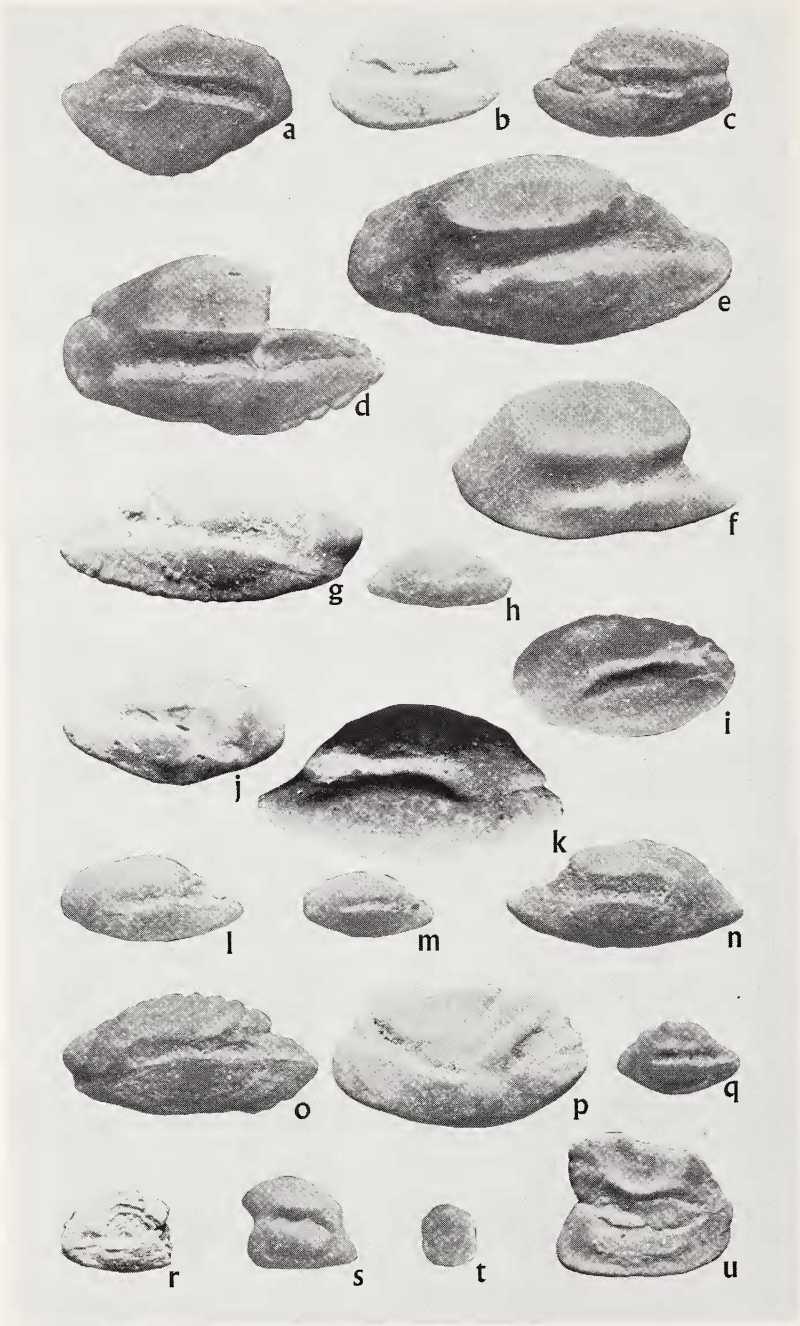
The halfblind goby ranges from Monterey Bay to about Cape Colnett, Baja California, but it is not very common north of Point Conception. Juveniles often have been observed in the water column in and around kelp beds, but adults are more secretive in their habits and usually remain hidden under rocks, in kelp holdfasts, and similar places. A large adult, slightly longer than 2 inches, will have sagittae longer than 1.4 mm. Otoliths of halfblind gobies have been found in a number of Pleistocene and Pliocene deposits in southern California (Fitch, unpublished data).

Material: 78 otoliths from 0.7 to 1.3 mm long (Fig. 2t).

Batrachoididae—toadfishes

Porichthys notatus Girard—plainfin midshipman

The plainfin midshipman ranges from southeastern Alaska to Cedros



Island, Baja California, being one of the half-dozen most abundant species trawled in 300 to 750 feet of water. A 13½-inch male (2 inches short of the reported maximum) weighed just over 14 ounces. *P. notatus* otoliths usually are abundant in southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, 1967, and unpublished data; Fitch and Reimer, 1967), nearly 700 having been recovered from the Lomita marl Pliocene at San Pedro (Fitch, unpublished data). The sagittae of a large, adult plainfin midshipman will exceed 10.0 in length.

Material: 101 otoliths from 1.5 to 6.0 mm long (Fig. 2u).

Stichaeidae—pricklebacks

Lyconectes aleutensis Gilbert—dwarf wrymouth

The dwarf wrymouth ranges from the Bering Sea to Eureka, California, usually at depths of 150 to 1,200 feet or more. The species apparently attains a length of 12 inches and a weight of about 2 ounces. Otoliths of *L. aleutensis* have been found in several other southern California Pliocene and Pleistocene deposits, but they are not abundant in any of these (Fitch, unpublished data). The sagittae of a large, adult dwarf wrymouth will exceed 5.0 mm in length.

Material: 25 otoliths from 2.8 to 5.2 mm long (Fig. 3a).

Zoarcidae—eelpouts

Lycodopsis pacifica (Collett)—blackbelly eelpout

The blackbelly eelpout ranges from the Gulf of Alaska to Ensenada (at least), being very abundant in trawl catches made in depths of 100 to 800 feet or more. The species is known to attain a size of 14 inches and nearly 1/3 pound. *L. pacifica* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, 1967, and unpublished data). The sagittae of an adult blackbelly eelpout will exceed 5.0 mm in length.

Material: 34 otoliths from 2.7 to 4.8 mm long (Fig. 3b).

Figure 2. Teleost sagittae found in Timms Point silt at San Pedro, California. Lengths (in mm) are given for each otolith, and notations are made regarding its position in the skull, and condition if imperfect. a. *Cymatogaster aggregata*, 5.2, r; b. *Oxyjulis californica*, 1.5, r; c. *Sebastes hopkinsi*, 4.5, r; d. *S. goodei*, 7.3, l; e. *S. rosaceus*, 8.7, l; f. *Sebastolobus* sp., 9.0, l, badly worn; g. *Artedius notospilotus*, 5.3, r; h. *Chitonotus pugetensis*, 3.2, l; i. *Enophrys taurina*, 5.0, l; j. *Icelinus burchami*, 3.9, r, badly eroded; k. *I. filamentosus*, 5.4, r, badly worn; l. *I. quadriseriatus*, 4.1, l; m. *I. tenuis*, 2.9, l; n. *I. fimbriatus*, 5.2, r; o. *Leptocottus armatus*, 5.8, l; p. *Malacocottus zonurus*, 8.0, l, badly worn; q. *Radulinus asprellus*, 2.8, l; r. *Xeneretmus* sp., 3.4, l, rostrum missing and badly eroded; s. *Coryphopterus nicholsi*, 2.8, r; t. *Lethops connectens*, 1.2, r; u. *Porichthys notatus*, 5.5, r. Photographs by Jack W. Schott.

Brotulidae—brotulas

Brosmophycis marginata (Ayres)—red brotula

The red brotula ranges from southeastern Alaska to Ensenada (at least), mostly in depths of 60 to 400 feet. Although reported to attain 18 inches, few individuals are seen that exceed 16 inches and 12 ounces. *B. marginata* otoliths have been found in several southern California Pliocene and Pleistocene deposits, but they are never abundant (Fitch, 1967, and unpublished data). The sagittae of a large, adult red brotula will exceed 14.0 mm in length.

Material: 15 otoliths from 1.4 to 5.8 mm long (Fig. 3c).

Ophidiidae—cusk-eels

Otophidium taylori (Girard)—spotted cusk-eel

The spotted cusk-eel ranges from about northern Oregon to San Cristobal Bay, Baja California, primarily in 60 to 800 feet of water. A near-record 14¼-inch specimen caught off San Pedro in 1960 weighed about 10 ounces. *O. taylori* otoliths are abundant in many southern California Pliocene and Pleistocene deposits (Fitch, 1964, 1966, and unpublished data; Fitch and Reimer, 1967; Kanakoff, 1956). The sagittae of a large, adult spotted cusk-eel will exceed 11.0 mm in length.

Material: 113 otoliths from 2.9 to 8.0 mm long (Fig. 3d).

Ammodytidae—sandlances

Ammodytes hexapterus Pallas—Pacific sandlance

The Pacific sandlance ranges from the Bering Sea to San Simeon, California, often occurring in schools from the surf zone to a considerable distance

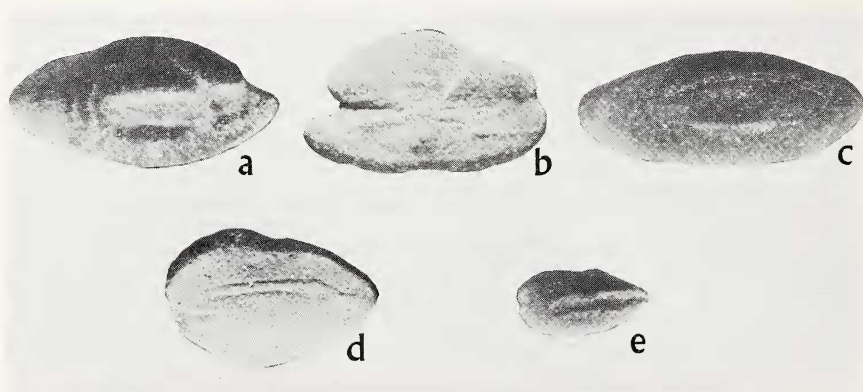


Figure 3. Teleost sagittae found in Timms Point silt at San Pedro, California. Lengths (in mm) are given for each otolith, and a notation is made as to whether it is left or right. a. *Lyconectes aleutensis*, 4.9, l; b. *Lycodopsis pacifica*, 4.4, r; c. *Brosmophycis marginata*, 5.2, l; d. *Otophidium taylori*, 5.6, r; e. *Ammodytes hexapterus*, 2.4, l. Photographs by Jack W. Schott.

offshore. The species is reported to attain a size of 8 inches and about $\frac{1}{2}$ ounce. *A. hexapterus* otoliths have been found in several southern California Pliocene and Pleistocene deposits (Fitch, unpublished data). The sagittae of a large, adult Pacific sandlance will exceed 3.0 mm in length.

Material: 8 otoliths from 1.4 to 3.2 mm long (Fig. 3e).

Unidentified teleosts

Two otoliths (very badly worn), 8 teeth, 121 vertebrae, and 1 fin spine recovered from this deposit could not be identified except as teleost remains. Most of these are presumed to have come from the same species that "left" their otoliths.

DISCUSSION

Nine of the more than 53 species of teleosts identified from the Timms Point silt belonged to two families of mesopelagic fishes (Myctophidae and Melamphaidae) that seldom are captured in depths shallower than about 1,000 feet. All of these are found in waters offshore from San Pedro as well as at latitudes to the north and south of this fossil deposit, and all but one, *Electrona rissoi*, are taken abundantly in midwater trawls. It is commonplace to find otoliths of one to three species of myctophids in southern California Pliocene and Pleistocene deposits, including those presumably laid down at relatively shallow depths (± 60 feet), but few deposits that I have investigated have contained melamphaid otoliths, or sagittae from as many myctophid species (7) as I found at this locality.

Otoliths of deep-sea fishes can arrive in moderately-deep or shallow deposits in any of several ways: (i) fishes can be eaten by a predator in deeper waters and their otoliths transported to a shallow area in the predator's digestive tract, which they can pass through in a relatively unaltered condition; (ii) when mass mortalities occur, the dead fishes can be transported to shallower areas by currents or wind action, or in the stomachs of scavengers; (iii) mesopelagics which undertake diurnal migrations are known to approach close to shore at night near the heads of submarine canyons or where the bottom gradient rises abruptly near shore—predation and mortality in these shallow waters will result in otoliths being deposited there; (iv) spawning migrations take some species into shallower waters than they inhabit the rest of the year; and (v) deep areas which contain otoliths of offshore species can be folded or faulted upward so that subsequent otolith deposition will be from shallow species (downfaulting of shallow bottom areas could also result in an admixture of otoliths from nearshore and offshore species).

Six of the 53 teleost species found in this deposit (*Ammodytes*, *Atheresthes*, *Lyconectes*, *Malacocottus*, *Microgadus*, and *Theragra*) have not been captured or noted south of about Monterey, California, during modern times (Figure 4). Only two of these (*Ammodytes* and *Microgadus*) are found in

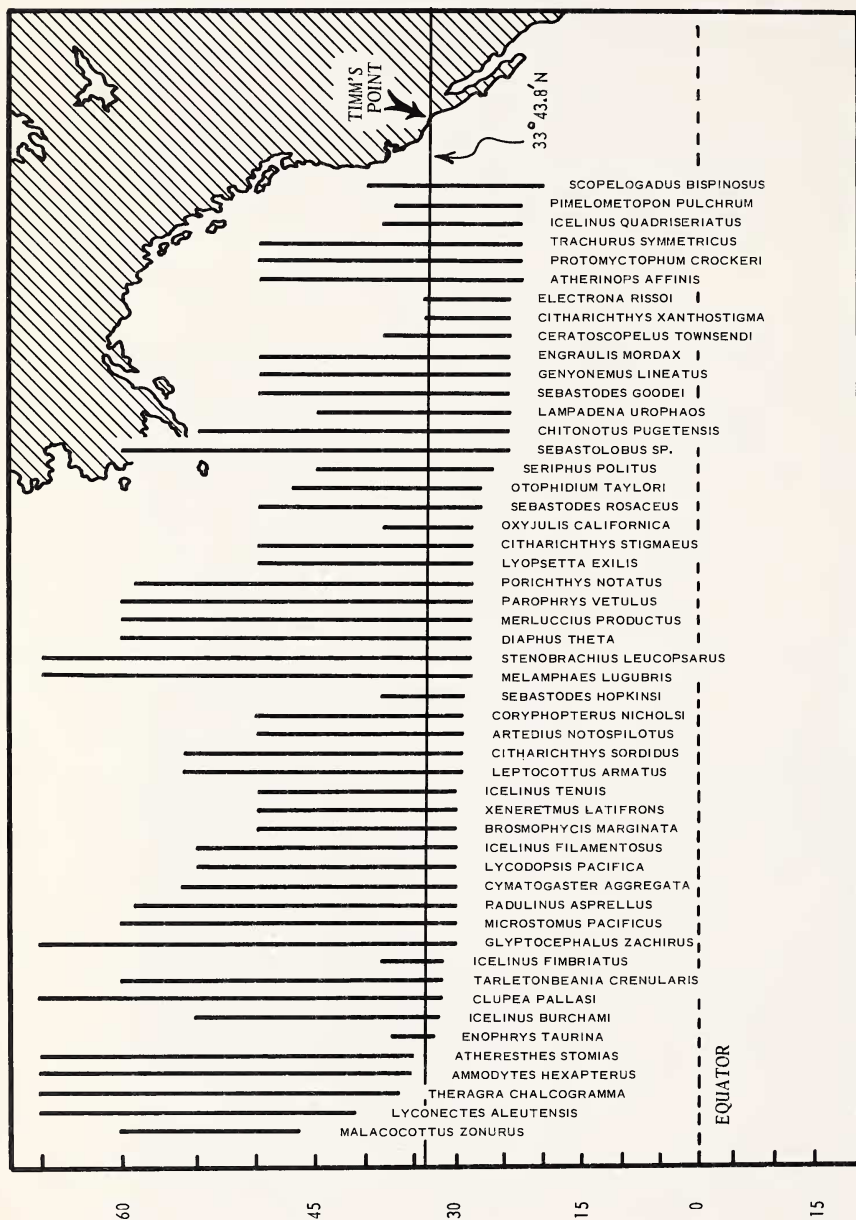


Figure 4. Present-day distributions of 51 of the 53 species of teleosts identified from Timms Point silt at San Pedro, California (lat. 33° 43.8' N.). Ololiths of *Lethops connectens* (Monterey Bay to Cape Colnett) and *Microgadus proximus* (Alaska to Morro Bay) were identified after this chart was completed.

relatively shallow water, but even these species are more abundant in offshore waters where depths exceed 100 feet.

Only 10 of the more than 53 species identified from this deposit were captured during 3 years of beach seining (451 hauls) along the southern California coast to depths of about 10 or 12 feet (Carlisle, Schott, and Abramson, 1960), but 7 of these 10 were also taken during otter-trawling operations in Santa Monica Bay using fine-mesh nets in 60 to 600 feet. In all, these otter-trawling operations captured 27 of the 53+ Timms Point species (Calif. Dept. Fish and Game unpublished data). Obviously the Timms Point fish fauna admirably supports the statement of Valentine (1961) and others that deposition occurred at depths between 25 and 100 fathoms at a time when water temperatures were considerably cooler than at present.

In view of the numbers of northern fishes (Figure 4, Table 1), it would be interesting to know how many individuals of a given species are needed in a square mile of ocean before an otolith of that species finds its way into a given area of bottom. If such data were available, it would be possible to speculate as to the density of *Lyconectes aleutensis* that resulted in 25 of their otoliths being found in the 1,000 pounds or so of fossiliferous matrix that was examined. It would also be interesting to know if the single arrowtooth flounder otolith would represent a comparable number of *Atheresthes stomias*. It seems reasonable to assume that otoliths of a prey species or potential prey species (e.g., *Ammodytes* and *Lyconectes*) will be present in greater numbers than those of a large predator (e.g., *Atheresthes*) which would have few natural enemies. Unfortunately, as has been pointed out by a multitude of investigators, fossil deposits represent only death associations, so conclusions as to life associations must be relegated to the realm of pure speculation unless accompanied by irrefutable proof. Such proof is lacking in the present case.

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